09/805760 PCT/PTO 16 MAR 2001

FORM PTO-1390 (REV 10-2000) U S DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE		ATTORNEYS DOCKET NUMBER 0670-257
TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371		U S APPLICATION NO (If known, see 37 CFR 1 5) 09/805760
INTERNATIONAL APPLICATION NO. PCT/JP99/05088	INTERNATIONAL FILING DATE September 17, 1999	PRIORITY DATE CLAIMED September 18, 1998

TITLE OF INVENTION

RADIO DIGITAL SIGNAL RECEIVER

APPLICANT(S) FOR DO/EO/US

Kenichi SHIRAISHI, Shoichi SUZUKI, Akihiro HORII, Shoji MATSUDA, Takahiro WADA

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to promptly begin national examination procedures (35 U.S.C. 371(f)).
4. ☒ The US has been elected by the expiration of 19 months from the priority date (PCT Article 31).
5. ☒ A copy of the International Application as filed (35 U.S.C. 371(c)(2))
   a. ☐ is attached hereto (required only if not communicated by the International Bureau).
   b. ☒ has been communicated by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☒ An English language translation of the International Application as filed (35 U.S.C. 371(c)(2)).
7. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371(c)(3)).
   a. ☐ are attached hereto (required only if not communicated by the International Bureau).
   b. ☐ have been communicated by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
8. ☐ An English language translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
9. ☒ An oath or declaration of the inventor(s) (35 U.S.C. 371(c)(4)).
10. ☐ An English language translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371(c)(5)).

Items 11 to 16 below concern document(s) or information included:

11. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
12. ☒ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
13. ☒ A FIRST preliminary amendment.
    ☐ A SECOND or SUBSEQUENT preliminary amendment.
14. ☐ A substitute specification.
15. ☐ A change of power of attorney and/or address letter.
16. ☒ Other items or information:
    Application Data Sheet
    Five sheets of formal drawings (Figs. 1-7)
    International Search Report

JC03 Rec'd PCT/PTO 16 MAR 2001

U.S. APPLICATION NO (If known, see 37 C F R 1 50)	INTERNATIONAL APPLICATION NO	ATTORNEYS DOCKET NUMBER
09/805766	PCT/JP99/05088	0670-257

17. [X] The following fees are submitted:

				CALCULATIONS	PTO USE ONLY
BASIC NATIONAL FEE (37 CFR 1.492(a)(1) – (5)): Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2)) paid to USPTO and International Search Report not prepared by the EPO or JPO .... **#1000.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but International Search Report prepared by the EPO or JPO .... **$860.00** International preliminary examination fee (37 CFR 1.482) not paid to USPTO but international search fee (37 CFR 1.445(a)(3)) paid to USPTO .... **$710.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) but all claims did not satisfy provisions of PCT Article 33(1)-(4) .... **$690.00** International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(1)-(4) **$100.00**					
ENTER APPROPRIATE BASIC FEE AMOUNT =				$860.00	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(e)).				$	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	11 - 20 =	0	X **$18.00**	$	
Independent claims	3 - 3 =	1	X **$80.00**	$	
MULTIPLE DEPENDENT CLAIM(S) (if applicable)			+ **$270.00**	$	
TOTAL OF ABOVE CALCULATIONS =				$860.00	
☐ Applicant claims small entity status. See 37 CFR 1.27. The fees indicated above are reduced by ½.				$	
SUBTOTAL =				$860.00	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492(f)). +				$	
TOTAL NATIONAL FEE =				$860.00	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31). **$40.00** per property +				$40.00	
TOTAL FEES ENCLOSED =				$900.00	
				Amount to be refunded:	$
				Charged:	$

a. [X] A check in the amount of $900.00 to cover the above fees is enclosed.

b. ☐ Please charge my Deposit Account No. ____________ in the amount of $__________ to cover the above fees. A duplicate copy of this sheet is enclosed.

c. [X] The Commissioner is hereby authorized to charge any additional fees which may be required, or credit any overpayment to Deposit Account No. 19-2380. A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

SEND ALL CORRESPONDENCE TO

SIGNATURE

Eric J. Robinson
NAME

38,285
REGISTRATION NUMBER

NVA174836.1

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

In re New Patent Application of	)
Kenichi SHIRAISHI et al.	)
International Application No. PCT/JP99/05088	) Attn: US/DO/EO
International Filing Date: September 17, 1999	)
For: RADIO DIGITAL SIGNAL RECEIVER	) Date: March 16, 2001

PRELIMINARY AMENDMENT

Honorable Commissioner for Patents
Washington, D.C. 20231

Sir:

Please preliminarily amend the subject application as follows:

IN THE CLAIMS:

Please amend the claims as follows:

Please note that the amended claims are presented below in their amended form. It is further presented as an Attachment to the Amendment whereby the amendments to the claims are outlined using the conventional method of bracketing and underlining.

Please cancel claim 1.

Claim 2. (Amended) A radio digital signal receiver, comprising:

means for estimating phase noise characteristics of an outdoor unit connected to a receiving terminal of the radio digital signal receiver on the basis of the bit error rate of a predetermined polyphase PSK-modulating signal at a time

when a received C/N has a predetermined value in a burst symbol reception mode for regenerating a carrier from a burst symbol signal; and

means for setting carrier regenerative loop characteristics on the basis of the estimated phase noise characteristics of the outdoor unit.

Claim 3. (Amended) The radio digital receiver according to claim 2, wherein said means for setting the loop characteristics sets a filter factor of a loop filter inserted into the carrier regenerative loop.

REMARKS

The claims have been amended in accordance with the Article 34 Amendment made during the International Phase.

Examination on the merits is therefore requested.

Respectfully submitted,

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VERSION WITH MARKINGS TO SHOW CHANGES MADE

Please cancel claim 1.

Claim 2. (Amended) [The radio digital signal receiver according to claim 1, wherein said estimating means estimates the phase noise characteristics of the outdoor unit on the basis of the bit error rate of a predetermined polyphase PSK-modulating signal at a time when a received C/N has a predetermined value in a burst symbol reception mode for regenerating a carrier from a burst symbol signal.]

A radio digital signal receiver, comprising:

means for estimating phase noise characteristics of an outdoor unit connected to a receiving terminal of the radio digital signal receiver on the basis of the bit error rate of a predetermined polyphase PSK-modulating signal at a time when a received C/N has a predetermined value in a burst symbol reception mode for regenerating a carrier from a burst symbol signal; and

means for setting carrier regenerative loop characteristics on the basis of the estimated phase noise characteristics of the outdoor unit.

Claim 3. (Amended) The radio digital receiver according to [claim 1 or claim 2] claim 2, wherein said means for setting the loop characteristics sets a filter factor of a loop filter inserted into the carrier regenerative loop.

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JC03 Rec'd PCT/PTO 16 MAR 2001

SPECIFICATION

RADIO DIGITAL SIGNAL RECEIVER

TECHNICAL FIELD

The present invention relates to a radio digital signal receiver and, more in particular, to a digital satellite broadcast receiver for changing characteristics of a carrier regenerative loop in accordance with a bit error rate at a received C/N (hereinafter, also described as an CNR).

BACKGROUND ART

The receiver for the digital satellite broadcast scheduled to start in the year 2000 is supposed to employ an antenna element for receiving the present analogue satellite broadcast and a down-converter for converting the output of the antenna element into BS-IF frequency, thereby receiving the digital satellite broadcast. Generally, the antenna element and the down-converter are installed outside and referred to as an outdoor unit. Hereinafter, the outdoor unit is also described as an ODU.

The receiving system for receiving the digital satellite broadcast, for example, the receiving system of CS broadcast stipulates that desirable phase noise characteristics of a local oscillator inside the down-converter used in the exclusive ODU have a phase noise (θrms)

within 4 degrees and, when the phase noise (θrms) is within 4 degree, the receiving performance of the receiver is scarcely affected.

On the other hand, in the receiving system of the digital satellite broadcast, the existing ODU for the analogue broadcast can be used and generally the performance of the existing ODU is not good. The characteristic distribution of the phase noise of the local oscillator of the existing antenna, which was sample-studied by Association of Radio Industries and Business (abbreviated as ARIB), was as shown in Figure 4.

At present there exists no standard concerning the phase noise for those planned as a new system. However, the phase noise characteristic thereof is expected to be the same degree as that of the above-described CS broadcast receiving system and, when the phase noise is not more than 4 degrees, the receiving performance of the receiver is not affected and no problem can be expected to arise. However, the existing ODU, especially the local oscillator having a large phase noise (θrms) damages the receiving performance of the receiver.

Shown in Figure 5 are the critical C/N characteristics by the phase noise (θrms) of the local oscillator inside the down-converter of the ODU for a 8PSK (Trellis coded 8PSK) modulating signal in a burst symbol reception. Here, the system for regenerating a carrier from only the BPSK modulating signal referred to as a burst symbol signal which is intermittently transmitted is termed the burst symbol reception. Shown in Figure 6 are critical C/N characteristics by the

phase noise (θrms) (of the local oscillator) for the 8PSK modulating signal in a continuation reception. Here, the continuation reception refers to a system for regenerating a carrier from a received signal.

In Figure 5, the characteristics of a carrier regenerative loop are shown by a critical CNR for each of three kinds of characteristics a, b and c. The characteristic a as shown in Figure 5 is a critical C/N where a noise bandwidth is made narrow and when the phase noise exceeds 15 degrees no reception is possible. The characteristic c as shown in Figure 5 is a critical C/N where the noise bandwidth is made large and a reception is possible even when the phase noise is about 30 degrees. However, a fixed deterioration at a time when the phase noise is about less than 10 degrees becomes large in contrast to the characteristic a as shown in Figure 5. The characteristic b as shown in Figure 5 is a critical C/N which is intermediate between the case of the characteristic a as shown in Figure 5 and the case of the characteristic c as shown in Figure 5.

As can be seen by comparing a of Figure 5 with Figure 6, in case of the burst reception, the receiving performance becomes deteriorated when the phase noise becomes large depending on the characteristics of the carrier regenerative loop, while in case of the continuation reception, even with the noise bandwidth of the characteristic a as shown in Figure 5, the fixed deterioration is lessened and the receiving performance is improved.

Now, the receiving system of the digital BS broadcast receiver will be described. In the digital BS broadcast system, a 8PSK

modulation, a QPSK modulation and a BPSK modulation are adapted as modulating systems and the modulated wave thereof is time-divisionally-multiplexed and transmitted as shown in Figure 7.

Figure 7(a) shows the configuration of one super frame, which comprises eight frames in total. In each frame, a BPSK-modulated frame synchronous pattern as shown by the first oblique lines (32 symbols), a BPSK-modulated TMCC pattern for discriminating a transmission and multiplex configuration (128 symbols), then a BPSK-modulated super frame discrimination pattern (32 symbols), a main signal of 203 symbols, a BPSK-modulated burst symbol signal as shown by cross-oblique lines (4 symbols) and subsequently a main signal and a burst symbol signal are repeated in order, thereby configuring one frame with 39936 symbols. The main signal as shown in Figure 7(b) is a 8PSK/QPSK/BPSK-modulating signal.

Because the modulated wave by a modulating system where the required C/N (the C/N required for demodulation) varies as the number of phases varies as eight, four and two like the 8PSK/QPSK/BPSK-modulating signal is time-divisionally-multiplexed, the BPSK-modulating signal of 4 symbols is embedded at a specific period (mainly at intervals of 203 symbols) in order to compensate for the carrier regenerative characteristics in the case where the modulating system having a number of phases is difficult to obtain reception especially at a low C/N time. The BPSK-modulating signal of the 4 symbols is termed a burst symbol signal and the system for regenerating a carrier from

only the BPSK-modulating signal which is referred to as the burst symbol signal is termed the burst symbol reception as described above.

As described above, in the place where there are few phase noises, the receiving performance (the critical CNR) remains almost unchanged in case of either the burst symbol reception or the continuation reception and no problem is expected to arise. However, in the place where there are many phase noises, quite different from the continuation reception, there arises a problem for the burst symbol reception in that the critical CNR fluctuates largely according to the characteristics a, b and c of the carrier regenerative loop.

This problem will be described further in detail. By scanning a carrier frequency through the AFC circuit inserted into the carrier regenerative loop, frame synchronization is established, and when carrier regeneration is made by the burst symbol reception, Reed-Solomon error of the main signal can be checked. If the received CNR is good, the Reed-Solomon error will be eliminated and the receiving system will be switched over from the burst symbol reception to the continuation reception.

Nevertheless, when the characteristic a as shown in Figure 5 is selected as the characteristic of the carrier regenerative loop, the Reed-Solomon error will occur in the case where the phase noise is large so that the receiving system can not be switched over to the continuation reception. As a result, the main signal is no longer

regenerated indefinitely. Note that what is meant by the critical CNR as shown in Figure 5 and Figure 6 is the critical value where the error rate after a trellis code is decoded is 2×10^{-4} and which, after the Reed-Solomon is decoded, becomes error- free.

On the other hand, when the characteristic c as shown in Figure 5 is selected as the characteristic of the carrier regenerative loop, the Reed-Solomon error will be eliminated if the received CNR is good even if the phase noise is large and the receiving system can be switched over to the continuation reception. However, as can be seen by comparing the characteristic c as shown in Figure 5 with the characteristic as shown in Figure 6, because the value of the critical CNR of the burst reception differs from the value of the critical CNR of the continuation reception practically irrespective of the phase noise characteristics, when the receiving system is switched over, hysteresis will occur.

However, in the situation where it is not clear which type of the ODU is to be used ultimately, it is safe to adapt the later, that is, (c) as shown in Figure 5 for the characteristic of the carrier regenerative loop so that, whichever type of reception systems is used, it can obtain a basic reception. As a result, in spite of the fact that the digital only or the existent high performance ODU is used, a problem arises in that the receiving performance is not improved.

An object of the present invention is to provide a digital satellite broadcast receiver capable of expecting an optimum reception when

the exclusive ODU or the existing high performance ODU is connected.

DISCLOSURE OF THE INVENTION

The radio digital signal receiver according to the present invention is characterized in that it comprises means for estimating phase noise characteristics at a reception time of the outdoor unit connected to a receiving terminal of the radio digital signal receiver from a decoded error rate of the digital signal and means for setting the characteristics of the carrier regenerative loop based on the estimated phase noise characteristics of the outdoor unit.

In the preferred embodiment of the radio digital signal receiver of the present invention, the above described estimating means estimate the phase noise characteristics of the outdoor unit based on a bit error rate of the specific polyphase PSK-modulating signal when the received CNR has a predetermined value in a burst symbol reception mode for regenerating a carrier from a burst symbol signal.

Also, the above means for setting the characteristics of the loop preferably sets a filter factor of a loop filter inserted into the carrier regenerative loop.

Moreover, in the preferred embodiment, the above described burst symbol signal is a BPSK-modulating signal and the above described specific polyphase PSK-modulating signal is a 8PSK-modulating signal.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 is a block diagram showing the configuration of a carrier regenerative portion in the digital satellite broadcast receiver according to an embodiment of the present invention;

Figure 2 is a flowchart provided for explaining the operation of the digital satellite broadcast receiver according to an embodiment of the present invention;

Figure 3 is a characteristic diagram showing a bit error rate due to the phase noise of a 8PSK-modulating signal in a burst symbol reception of the digital satellite broadcast receiver according to an embodiment of the present invention;

Figure 4 is a distribution diagram of the phase noise characteristics of an ODU;

Figure 5 is a characteristic diagram showing a critical CNR by the phase noise of the 8PSK-modulating signal in the burst symbol signal;

Figure 6 is a characteristic diagram showing the critical CNR by the phase noise of the 8PSK-modulating signal in a continuation reception; and

Figure 7 is a type view showing a modulating signal array in the digital satellite broadcast.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Hereinafter, a digital satellite broadcast receiver will be described based on the preferred embodiment.

Figure 1 is a block diagram showing the configuration of a carrier regenerative portion in the digital satellite broadcast receiver according to an embodiment of the present invention.

The base band signals I, Q which are orthogonally detected and A/D converted in a tuner portion are inputted to a complex-number arithmetic operation circuit 1, and the base band signals I, Q, a sine wave data $\sin\theta$ which is a practically recovered carrier data outputted from a numeric control oscillator (NCO) 2 and a cosine wave data $\cos\theta$ are processed with Ir (= $I\cos\theta + Q\sin\theta$) arithmetic operation and Qr (=$I\sin\theta + Q\cos\theta$) arithmetic operation in the complex-number arithmetic operation circuit 1 and quasi-synchronously detected, so to speak, thereby outputting the base band signals Ir, Qr from the complex-number arithmetic operation circuit 1.

The base band signals Ir, Qr which are outputted from the complex-number arithmetic operation circuit 1 are supplied respectively to band limiting filters 3-1, 3-2 which comprise digital filters and band-limited. The base band signals Id, Qd which were band-limited at the band limiting filters 3-1, 3-2 are supplied to a decoder 4, a CNR measurement circuit 5 and a phase error detection circuit 6. The decoder 4 performs the decoding of the frame synchronous pattern and the TMCC pattern and sends a 8PSK signal resulting from the decoding to a trellis decoder 7 and at the same time sends a modulation discrimination data as to whether it is

8PSK, QPSK or BPSK to a control circuit 8 which comprises a micro computer and sends an enable signal to a loop filter 9.

The CNR measurement circuit 5 measures a CNR based on the distribution of vector by the inputted base band signals Id, Qd and sends the CNR data based on the CNR to the control circuit 8. The phase error detection circuit 6 is practically a look-up table and sends a phase error data, which is a phase difference between a receiving point comprising the inputted base band signals Id, Qd and a point where the received signals are to be converged, to the control circuit 8 and the loop filter 9. The trellis decoder 7 trellis-decodes the 8PSK-modulating signal and sends a bit error rate data (BER) of the transmission path in a 8PSK-modulating section to the control circuit 8.

On the other hand, the phase error data detected in the phase error detection circuit 6 is sent to the loop filter 9, which comprises a digital filter. The output of the loop filter 9 processed with a filter treatment in the loop filter 9 is sent to an automatic frequency control circuit 10, and the output from the automatic frequency control circuit 10 is sent to the numeric control oscillator 2. The numeric control oscillator 2 outputs a $\sin\theta$ data and a $\cos\theta$ data based on the output from the automatic frequency control circuit 10 and supply them to the complex-number arithmetic operation circuit 1.

The base band signals I, Q which receive the oscillating output from a fixed frequency oscillator and orthogonally detected and are

rotating at the frequency which is the difference between the oscillating frequency of the fixed frequency oscillator and an actual carrier frequency, the sinθ data and the cosθ data are calculated in the complex-number arithmetic operation circuit 1, thereby forming and outputting base band signals Ir, Qr which are synchronized by being rotated in reverse to the above described rotation.

The control circuit 8 sends a normal reception signal indicating that it is in a normal receiving state to the decoder 4 and, upon receipt of the modulation discrimination data outputted from the decoder 4, the CNR data outputted from the CNR measurement circuit 5, the phase error data outputted from the phase error detection circuit 6 and the bit error rate data outputted from the trellis decoder, controls itself for a burst symbol reception when it is not in a normal receiving state and makes the decoder 4 to supply an enable signal to the loop filter 9 during the burst symbol reception, thereby controlling the loop filter 9 in an enable state.

Moreover, upon receipt of the modulation discrimination data, the CNR data, the phase error data and the bit error rate data, the control circuit 8 controls itself for the burst symbol reception when it is not in a sate of normal reception. At the same time, based on the CNR data and the bit error rate data, it functionally comprises detection means for substantially detecting the phase noise characteristics of the ODU and characteristics setting means for setting the characteristics of the carrier regenerative loop based on the detected phase noise characteristics of the ODU, thereby setting

the filter characteristics of the loop filter 9 to the optimum filter characteristics based on the phase noise characteristics of the ODU. Also, the control circuit 8 sends a control signal to the automatic frequency control circuit 10 and performs the scanning of a carrier frequency.

Next, for example, the bit error rate characteristics by the phase noise of the 8PSK in the burst symbol reception at a time when the CNR is 15dB are as shown in Figure 3. The characteristics a, b and c as shown in Figure 3 are the bit error rates in the case where they are respectively set to the characteristics a, b and c as shown in Figure 5. The characteristic a as shown in Figure 3 corresponds to the characteristic a as shown in Figure 5 and the characteristic b as shown in Figure 3 corresponds to the characteristic b as shown in Figure 5 and the characteristic c as shown in Figure 3 corresponds to the characteristic c as shown in Figure 5.

Next, the operation of the digital satellite broadcast receiver according to an embodiment of the present invention will be described based on Figure 2.

At an initial state, that is, when a receiving state is not in a normal receiving state, it is controlled for the burst symbol reception and the loop filter 9 is controlled for the enable state and then the filter factor of the loop filter 9 is set to the characteristic where the characteristics of the carrier regenerative loop correspond to the characteristic c of Figure 5 (step S1). Following the step S1, a

received CNR is determined from the CNR data and a waiting is made till the determined CNR becomes 15dB. When the determined CNR becomes 15dB (step S2), a transmission and multiplexing configuration control (TMCC) pattern is decoded (step S3) and a presence of the 8PSK signal is confirmed (step S4).

Next, the 8PSK-modulating signal is burst-received and its bit error rate data is detected (step S5). This bit error rate data is a bare bit error rate of a transmission path and can be obtained from the trellis decoder 7. It is checked to see if it is better than the bit error rate for the received CNR (step S6). This is the case where the characteristics of the carrier regenerative loop are set to the characteristic c and the detected bit error rate is checked to see if it is, for example, equal to or less than 8×10^{-3}.

In the step S6, when the detected bit error rate is recognized to be better than a predetermined bit error rate for the received CNR, that is, for example, when the bit error rate is recognized to be equal to or less than 6.8×10^{-3}, the phase noise characteristics of the ODU connected to the receiver are determined to be good so that the filter factor of the loop filter 9 is set to the characteristic where the characteristics of the carrier regenerative loop correspond to the characteristic b of Figure 5. Then the 8PSK-modulating signal is burst-received again and its bit error rate is detected (step S7) and the detected bit error rate is checked to see if it is better than the predetermined bit error rate (step S8). This is the case where the characteristics of the carrier regenerative loop are set to the

characteristic b and the detected bit error rate is checked to see if it is, for example, equal to or less than 5.5×10^{-3}.

In the step S6, when the detected bit rate is recognized not to be better than the predetermined bit error rate for the received CNR, that is, for example, when the detected bit error rate is recognized to be more than 6.8×10^{-3}, the phase noise characteristics of the ODU connected to the receiver are determined not to be good so that the burst reception mode is released while the characteristics of the carrier regenerative loop remain set to the characteristic c of Figure 5, thereby executing a normal reception mode to start the normal reception (step S13).

In the step S8, when the detected bit error rate is recognized to be better than the predetermined bit error rate for the received CNR, that is, when the detected bit error rate is recognized to be equal to or less than 5.5×10^{-3}, the phase noise characteristics of the ODU connected to the receiver are determined to be fairly good so that the filter factor of the loop filter 9 is set to the characteristic where the characteristics of the carrier regenerative loop correspond to the characteristic a of Figure 5. Then the 8PSK-modulating signal is burst-received again and its bit error rate is detected (step S9) and the detected bit error rate is checked to see if it is better than the predetermined bit error rate (step S10). This is the case where the characteristics of the carrier regenerative loop are set to the characteristic a and the detected bit error rate is checked to see if it is, for example, equal to or less than 4.5×10^{-3}.

In the step S8, when the detected bit error rate is recognized not to be better than the predetermined bit error rate for the received CNR, that is, for example, when the detected bit error rate is recognized to be more than 5.5×10^{-3}, the phase noise characteristics of the ODU connected to the receiver are determined not to be good so that the characteristics of the carrier regenerative loop are restored to the characteristic c of Figure 5 (step S11) and the burst reception mode is released, thereby executing the normal reception mode to start the normal reception (step S13).

In the step S10, when the detected bit error rate is recognized to be better than the predetermined bit error rate for the received CNR, that is, for example, when the detected bit error rate is recognized to be equal to or less than 4.5×10^{-3}, the phase noise characteristics of the ODU connected to the receiver are determined to be good so that the burst reception mode is released while the characteristic of the carrier regenerative loop remains set to the characteristic a of Figure 5, thereby executing the normal reception mode to start the normal reception (step S13).

In the step S10, when the detected bit error rate is recognized not to be better than the predetermined bit error rate, that is, for example, when the detected error rate is recognized to be more than 4.5×10^{-3}, the performance of the ODU connected to the receiver are determined not to be good so that the characteristics of the carrier regenerative loop are restored so as to be set to the characteristic b of Figure 5 (step S12) and the burst reception mode is released,

thereby executing the normal reception mode to start the normal reception (step S13).

As described above, according to the digital satellite broadcast receiver in accordance with one aspect of the embodiment of the present invention, when the receiving condition is good (at a high CNR), the 8PSK-modulating signal is received in the burst reception mode and its bit error rate is measured to practically determine the phase noise of the ODU connected to the receiver. Therefore, the phase noise thus measured has a reliability and can be set to an optimum characteristic of the carrier regenerative loop in case of using the digital only or the existing high performance ODU, thereby lowering a received critical CNR and improving the probability of reception. Also, because the phase noise is not set to the characteristics of the carrier regenerative loop which exceed the critical CNR even during the reception, there will be no problem even if it is measured during the reception. Accordingly, when the phase noise characteristics of the ODU is good, the variations in the bit error rate due to the difference of the receiving system (burst or continuation) can be restricted to the minimum.

As described above, according to the radio digital signal receiver in accordance with the present invention, the phase noise characteristics of the ODU is detected and the detected characteristic of the phase noise of the ODU is set to the optimum characteristic of the carrier regenerative loop, thereby achieving the effect of lowering the received critical CNR and improving a receiving performance.

As described above, while the configuration and the operation of the present invention was wholly described with reference to the digital satellite broadcast receiver as an example, the application of the present invention is not limited to the digital satellite broadcast receiver. It should be understood that the technological scope of the present invention is not limited to the above-exemplified embodiment, but that the present invention is applicable widely to the whole of the radio digital receivers without deviating from its principle.

CLAIMS

1. A radio digital signal receiver, comprising:

means for estimating phase noise characteristics of an outdoor unit connected to a receiving terminal of the radio digital signal receiver from a decoded error rate of a digital signal; and

means for setting carrier regenerative loop characteristics on the basis of the estimated phase noise characteristics of the outdoor unit.

2. The radio digital signal receiver according to claim 1, wherein said estimating means estimates the phase noise characteristics of the outdoor unit on the basis of the bit error rate of a predetermined polyphase PSK-modulating signal at a time when a received C/N has a predetermined value in a burst symbol reception mode for regenerating a carrier from a burst symbol signal.

3. The radio digital signal receiver according to claim 1 or claim 2, wherein said means for setting the loop characteristics sets a filter factor of a loop filter inserted into the carrier regenerative loop.

4. The radio digital signal receiver according to claim 3, wherein said burst symbol signal is a BPSK-modulating signal.

5. The radio digital signal receiver according to claim 3, wherein said predetermined polyphase PSK-modulating signal is a 8PSK-modulating signal.

6. A radio digital signal receiver comprising a carrier regenerator, a demodulator for demodulating a received modulated wave signal and a decoder for taking a digital signal from the demodulated signal, further comprising:

means for detecting a C/N of the received modulated wave on the basis of said demodulated signal;

means for detecting the decoded error rate of the digital signal;

means for determining the magnitude of the decoding error rate of said digital signal when the detected C/N takes a predetermined value; and

means for changing a loop characteristic for said carrier regenerator on the basis of the determined result of the magnitude of said decoding error rate.

7. The digital radio signal receiver according to claim 6, wherein said decoding error rate to be detected is the bit error rate of a predetermined polyphase PSK-modulating signal which is demodulated in the burst symbol reception mode for regenerating a carrier from the burst symbol signal.

8. The radio digital signal receiver according to claim 6 or claim 7, wherein means for changing said loop characteristics changes the filter factor of a loop filter inserted into the carrier regenerative loop.

9. The radio digital signal receiver according to claim 7, wherein said burst symbol signal is a BPSK-modulating signal.

10. The radio digital signal receiver according to claim 7, wherein said predetermined polyphase PSK-modulating signal is the 8PSK-modulating signal.

11. A signal processing method used in the radio digital signal receiver for demodulating a received modulated signal by using a regenerated carrier and decoding a digital signal from a demodulated signal, said method comprising the steps of:

detecting a C/N of said received modulated signal on the basis of said demodulated signal;

determining whether said detected C/N coincides with the predetermined value;

when said C/N coincides with said predetermined value,

detecting a decoded error rate of said digital signal;

comparing the magnitude of the detected decoded error rate with the predetermined threshold value; and

changing the characteristic of the carrier regenerative loop on the basis of said compared result.

ABSTRACT

A digital satellite broadcast receiver capable of an optimum signal reception even when an arbitrary outdoor unit is connected. Please noise characteristics of an outdoor unit connected to a digital satellite broadcast receiver when receiving a burst symbol is estimated based on a bit error rate of an 8PSK modulation signal determined by a trellis decoder (7) when a CNR measured by a CNR measurement circuit (5) is equal to a preset value, and, based on the estimated phase noise characteristics of the outdoor unit, a filter factor of a loop filter (9) inserted into a carrier regenerative loop is set.

FIG. 1

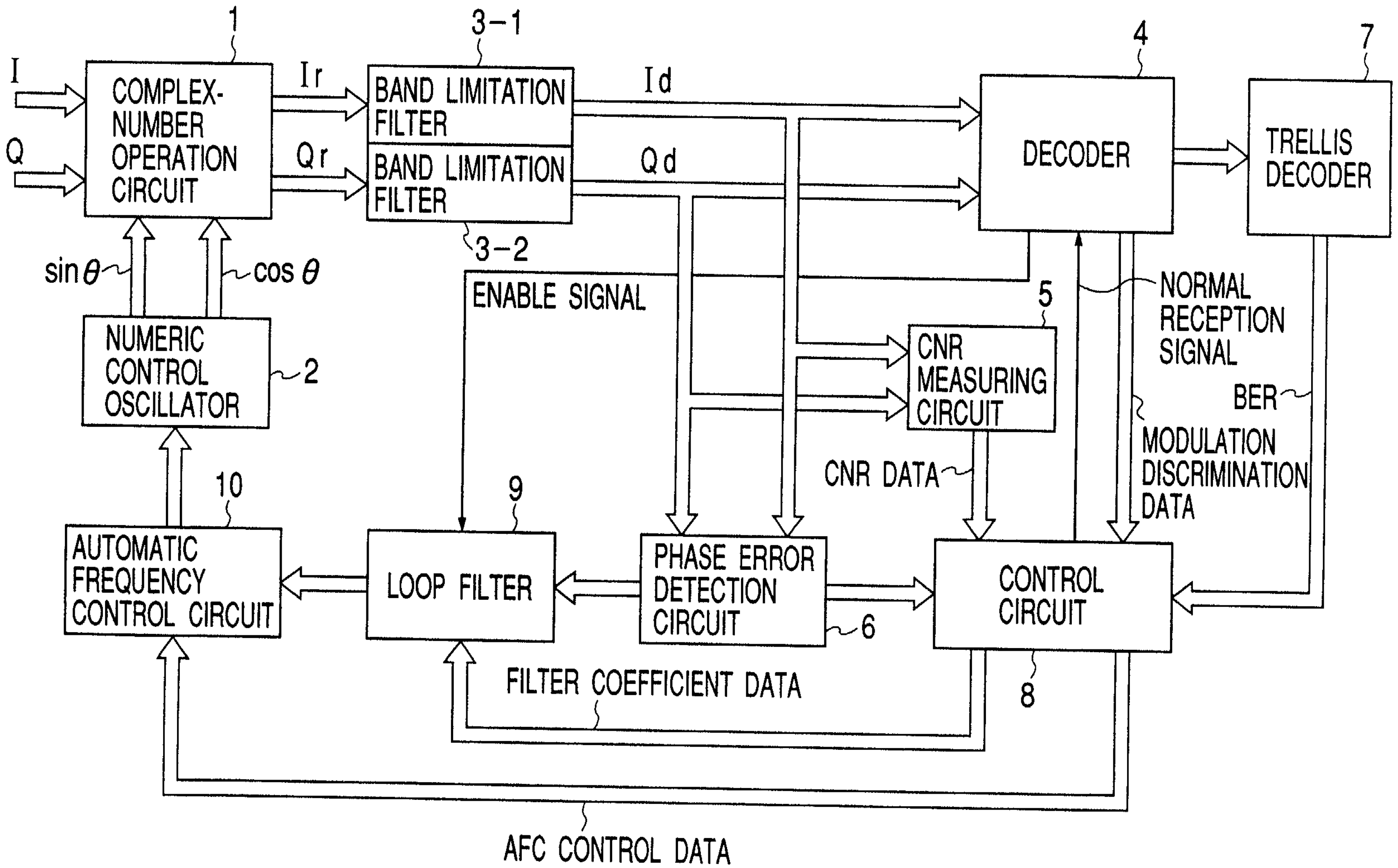

I
Q
COMPLEX-NUMBER OPERATION CIRCUIT
1
Ir
Qr
BAND LIMITATION FILTER
3−1
BAND LIMITATION FILTER
3−2
Id
Qd
DECODER
4
TRELLIS DECODER
7
sin θ
cos θ
NUMERIC CONTROL OSCILLATOR
2
ENABLE SIGNAL
CNR MEASURING CIRCUIT
5
NORMAL RECEPTION SIGNAL
BER
MODULATION DISCRIMINATION DATA
CNR DATA
AUTOMATIC FREQUENCY CONTROL CIRCUIT
10
LOOP FILTER
9
PHASE ERROR DETECTION CIRCUIT
6
CONTROL CIRCUIT
8
FILTER COEFFICIENT DATA
AFC CONTROL DATA

FIG. 2

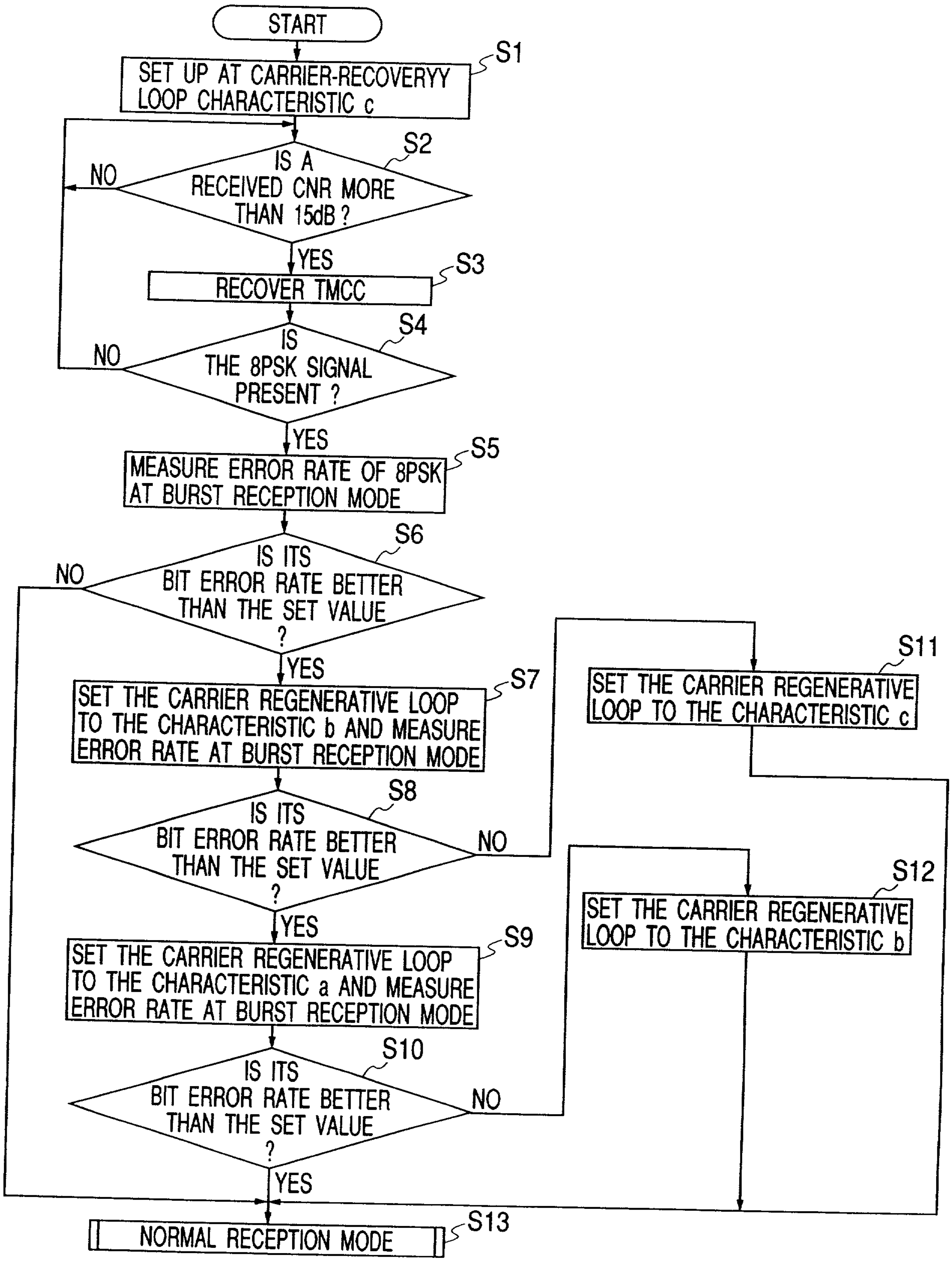
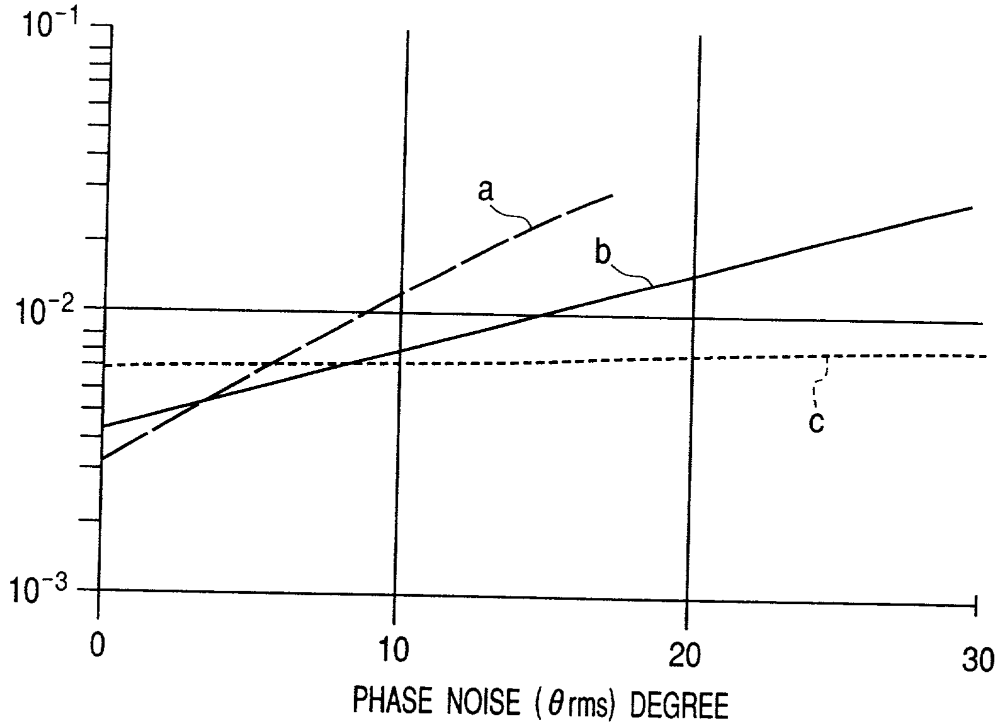
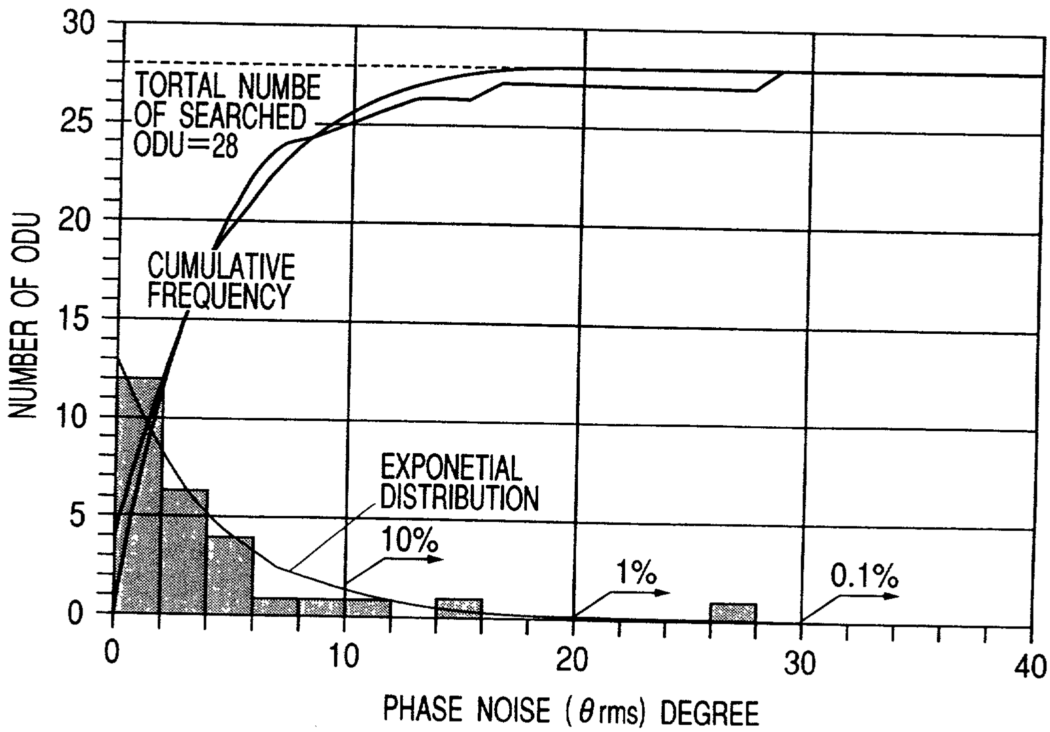

START
SET UP AT CARRIER-RECOVERYY LOOP CHARACTERISTIC c
S1
IS A RECEIVED CNR MORE THAN 15dB ?
S2
NO
YES
RECOVER TMCC
S3
IS THE 8PSK SIGNAL PRESENT ?
S4
NO
YES
MEASURE ERROR RATE OF 8PSK AT BURST RECEPTION MODE
S5
IS ITS BIT ERROR RATE BETTER THAN THE SET VALUE ?
S6
NO
YES
SET THE CARRIER REGENERATIVE LOOP TO THE CHARACTERISTIC b AND MEASURE ERROR RATE AT BURST RECEPTION MODE
S7
IS ITS BIT ERROR RATE BETTER THAN THE SET VALUE ?
S8
NO
YES
SET THE CARRIER REGENERATIVE LOOP TO THE CHARACTERISTIC a AND MEASURE ERROR RATE AT BURST RECEPTION MODE
S9
IS ITS BIT ERROR RATE BETTER THAN THE SET VALUE ?
S10
NO
YES
SET THE CARRIER REGENERATIVE LOOP TO THE CHARACTERISTIC c
S11
SET THE CARRIER REGENERATIVE LOOP TO THE CHARACTERISTIC b
S12
NORMAL RECEPTION MODE
S13

FIG. 3



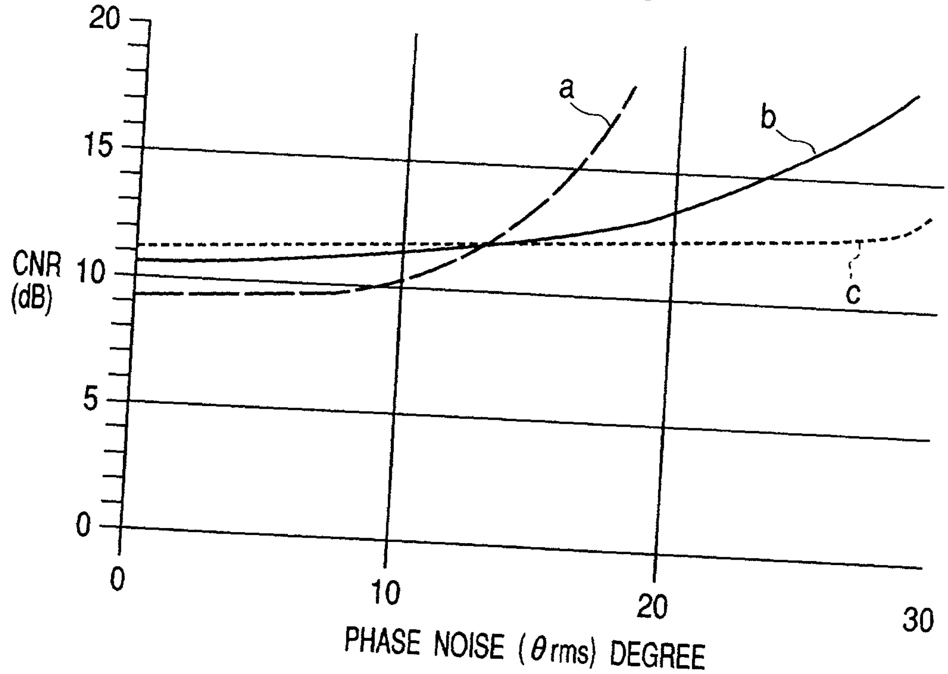
10^{-1}
10^{-2}
10^{-3}
a
b
c
0
10
20
30
PHASE NOISE (θrms) DEGREE

FIG. 4



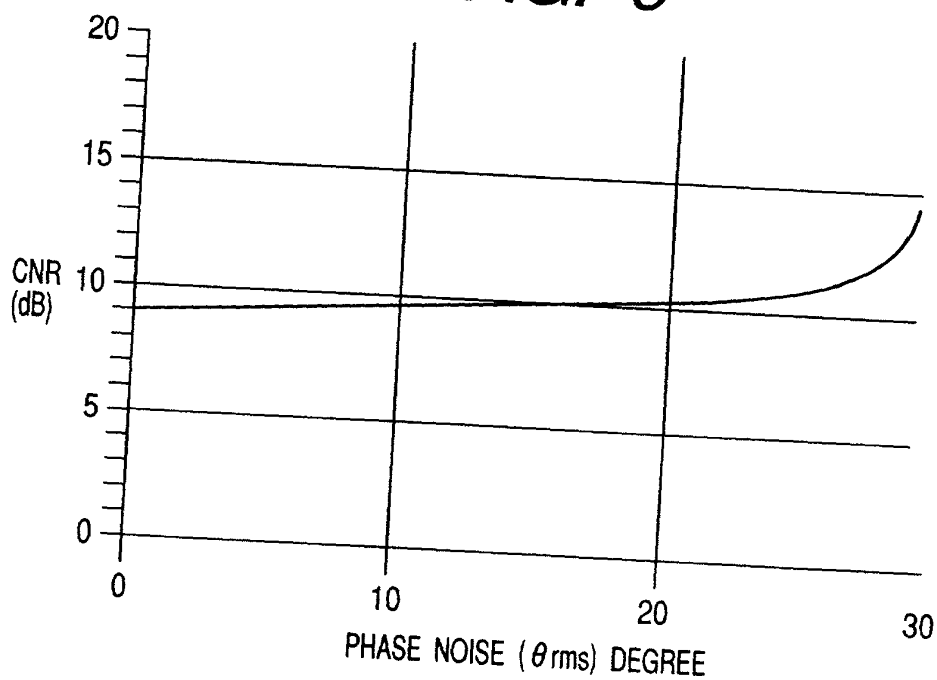
TORTAL NUMBE OF SEARCHED ODU=28
CUMULATIVE FREQUENCY
EXPONETIAL DISTRIBUTION
10%
1%
0.1%
NUMBER OF ODU
0
5
10
15
20
25
30
0
10
20
30
40
PHASE NOISE (θrms) DEGREE

FIG. 5



20
15
10
5
0
CNR (dB)
a
b
c
0
10
20
30
PHASE NOISE (θrms) DEGREE

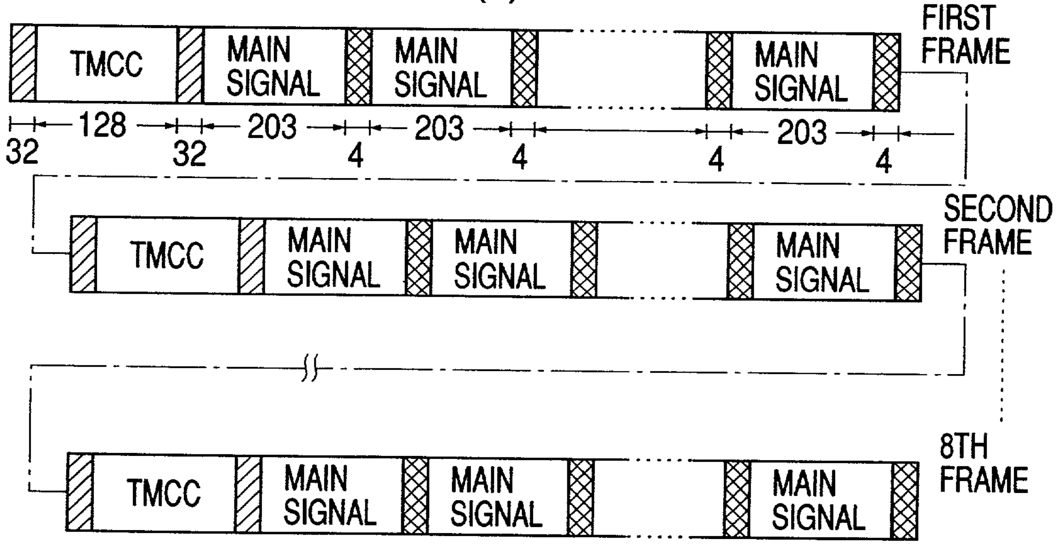
FIG. 6



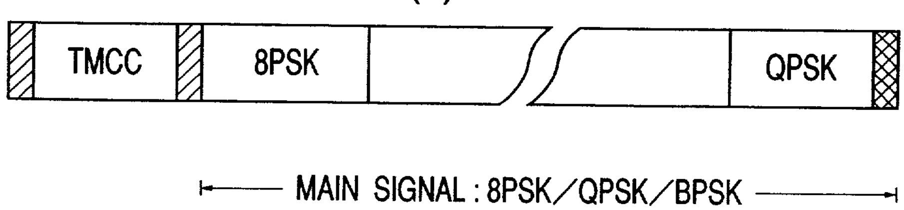
20
15
10
5
0
CNR (dB)
0
10
20
30
PHASE NOISE (θrms) DEGREE

FIG. 7

(a)


TMCC
MAIN SIGNAL
MAIN SIGNAL
MAIN SIGNAL
FIRST FRAME
32
128
32
203
4
203
4
4
203
4
SECOND FRAME
8TH FRAME

(b)


TMCC
8PSK
QPSK
MAIN SIGNAL : 8PSK／QPSK／BPSK

KW217 PC. US(2)

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY (Includes Reference to PCT International Applications)	Attorney Docket No·

As a below named inventor, I hereby declare that:

My residence post office address and citizenship are as stated below next to my name,

I believe I am the original, first and sole inventor (if only one name is listed below) or an original, first and joint inventor (if plural names are listed below) of the subject matter which is claimed and for which a patent is sought on the invention entitled: RADIO DIGITAL SIGNAL RECEIVER

the specification of which (check only one item below):

[ ] is attached hereto.

[ ] was filed as United States application

Serial No.
on
and was amended
on ______ (if applicable).

[X] was filed as PCT international application

Number PCT/JP99/05088
on September 17, 1999
and was amended under PCT Article 34
on September 20, 2000 (if applicable).

I hereby state that I have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

I acknowledge the duty to disclose information which is material to the examination of this application in accordance with Title 37, Code of Federal Regulations. § 1.56.

I hereby claim foreign priority benefits under Title 35, United States Code, § 119 of any foreign application(s) for patent or inventor's certificate or of any PCT international applications(s) designating at least one country other than the United States of America listed below and have also identified below any foreign application(s) for patent or inventor's certificate or any PCT international application(s) designating at least one country other than the United States of America filed by me on the same subject matter having a filing date before that of the application(s) of which priority is claimed:

PRIOR FOREIGN/PCT APPLICATION(S) AND ANY PRIORITY CLAIMS UNDER 35 U.S.C. 119:

COUNTRY	APPLICATION NUMBER	DATE OF FILING (day, month, year)	PRIORITY CLAIMED UNDER 35 USC 119
Japan	Patent Appln. No. 10-282046	18. 09. 98	[x] YES [ ] NO
			[ ] YES [ ] NO
			[ ] YES [ ] NO
			[ ] YES [ ] NO
			[ ] YES [ ] NO

COMBINED DECLARATION FOR PATENT APPLICATION AND POWER OF ATTORNEY
(Includes Reference to PCT International Applications)

Attorney Docket No.

I hereby claim the benefit under Title 35, United States Code, § 119(e) or § 120, as applicable of any United States application(s) or PCT international application(s) designating the United States of America that is/are listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in that/those prior application(s) in the manner provided by the first paragraph of Title 35, United States Code, § 112, I acknowledge the duty to disclose material information as defined in Title 37, Code of Federal Regulations, § 1.56 which occurred between the filing date of the prior application(s) and the national or PCT international filing date of this application:

PRIOR U.S. APPLICATIONS OR PCT INTERNATIONAL APPLICATIONS DESIGNATING THE U.S. FOR BENEFIT UNDER 35 U.S.C. 120:

U.S. APPLICATIONS			STATUS *(Check one)*		
U.S. APPLICATION NUMBER	U.S. FILING DATE		PATENTED	PENDING	ABANDONED
PCT APPLICATIONS DESIGNATING THE U.S.					
PCT APPLICATION NO.	PCT FILING DATE	U.S. SERIAL NUMBERS ASSIGNED *(if any)*			

POWER OF ATTORNEY: As a named inventor, I hereby appoint the following attorney(s) and/or agent(s) to prosecute this application and transact all business in the Patent and Trademark Office connected therewith. (*List name and registration number*)

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I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

The undersigned hereby authorize any U.S. attorney or agent named herein to accept and follow instructions from Nobuaki KATO and Nobumitsu ASAHI as to any action to be taken in the Patent and Trademark Office regarding this application without direct communication between the U.S. attorney or agent and the undersigned. In the event of a change in the persons from whom instructions may be taken, the U.S. attorneys or agents named herein will be so notified by the undersigned.

1-00

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POST OFFICE ADDRESS (Complete Address including City, State & Country)		

FULL NAME OF EIGHTH JOINT INVENTOR (if any)	INVENTOR'S SIGNATURE	DATE
RESIDENCE (City, State & Country)		CITIZENSHIP
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